

# **Lights-Out Operations for Transition Region and Coronal Explorer (TRACE) Using Both Operational and Architectural Approaches**

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# Overview

- Background
- Technology Roadmap
- Changes from Previous Missions
- Remote Notification
- Functions Automated
- Resulting Operational Changes
- Early Lessons Learned
- Future Work

# **Background**

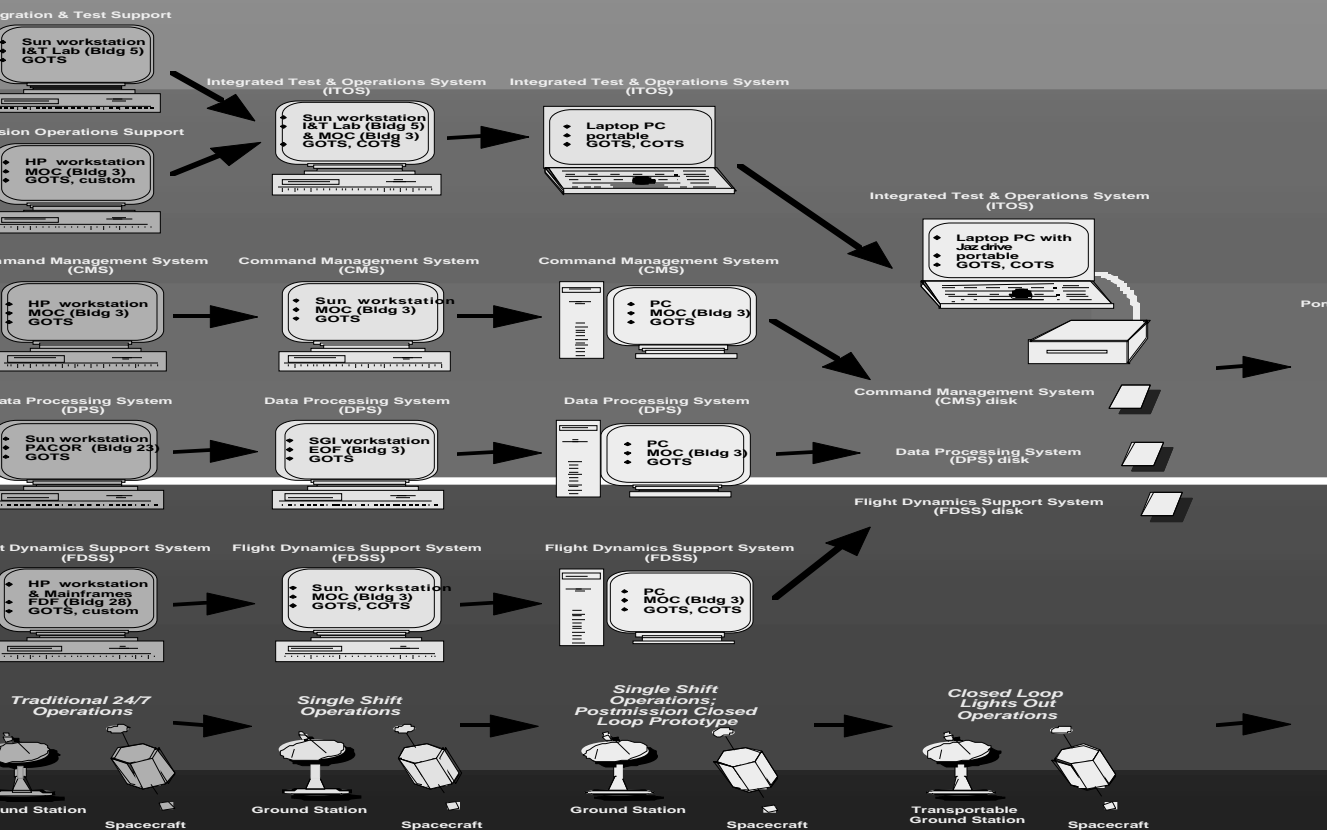
- TRACE (Transition Region and Coronal Explorer) launched on April 1, 1998.
- TRACE will study the magnetic structures which emerge through the solar surface and define both the geometry and dynamics of the upper atmosphere.
- 650x 600 km sun-synchronous orbit
- Six, ten-minute ground contacts per day with Poker Flat, Alaska and Wallops Island, Virginia
- After the completion of the commissioning phase (mid-May), TRACE operations will transition to 5 day-operations with lights-out operations for weekends and evenings.

# **Technology Roadmap**

- TRACE is the 4th of the Small Explorer (SMEX) missions
- The SMEX team developed a technology roadmap towards automation and cost reduction for the SMEX mission
- The roadmap facilitated planning towards a simplified ground system
  - Demonstrated by the original SMEX architecture versus the current TRACE ground system architecture

# SMEX Ground Data Systems Technology

SWAS      TRACE      WIRE      SMEX-Li



**Completed**

**In Progress**

**Planned**

- Platform
- Facility Location
- System Source

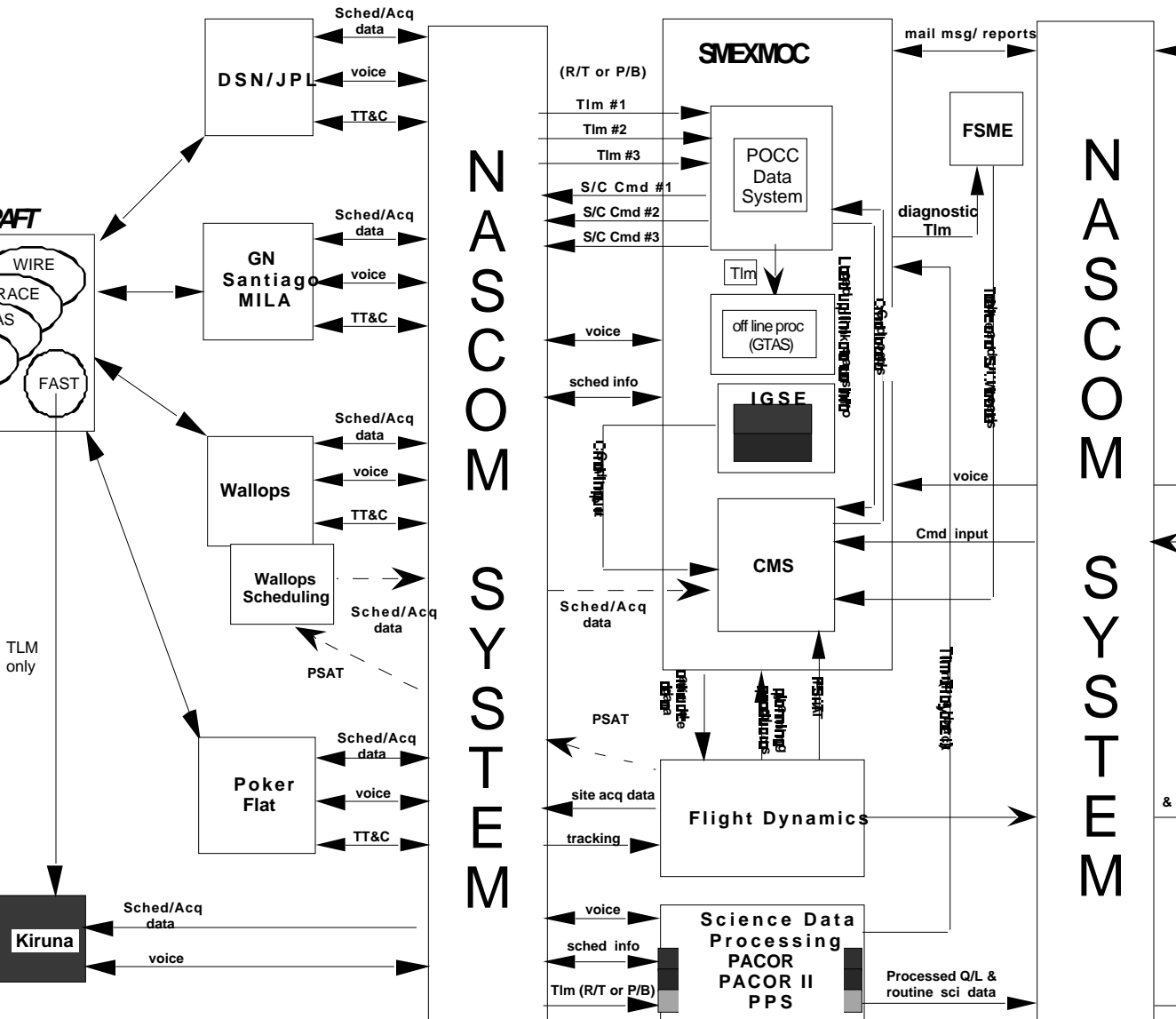
## Primary Objectives

- Provide Flexible Operations Environment**
- Desktop environment (workstations, PCs, laptops)
  - Single integrated operations facility
  - Portable systems (office, home, PI facility)

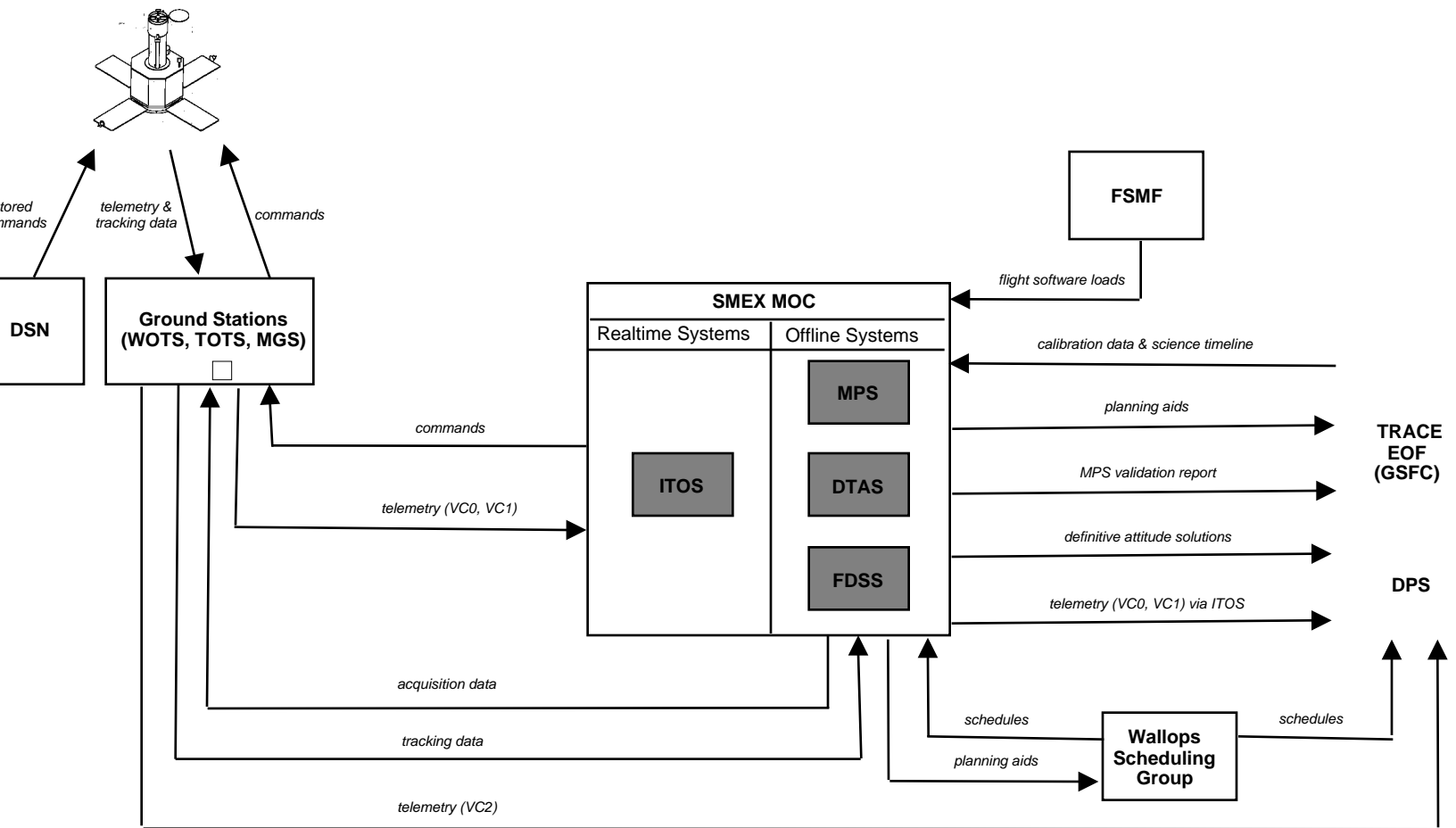
- Transition to Less Expensive**
- OS: HP/UX => Solaris => Solaris
  - COTS: LabVIEW, STK, WWW

- Targeted Features**
- Lights-out operations capability
  - Turn-key operation
  - Distributed, intelligent spacecraft control environment
  - User configurable
  - Spacecraft viewed as node on operations network

# SMEX Ground Data System



# TRACE Ground Data System Architecture



# **Changes from Previous Missions**

- **Common Ground System**
  - Same ground system, ITOS (Integrated Test and Operations System), used for I&T as operations
    - Greatly assisted in ops preparation
    - Allowed procedures and concepts to be tested during I&T
  - Result: FOT can more realistically test new ops concepts during the I&T phase



# **Changes from Previous Missions**

- **Easily Transportable Hardware**
  - ITOS hosted on both work stations and PC's (desktop and laptop)
    - Cheaper
    - Added flexibility for MOC (Mission Operations Center) and engineering support room design
    - MOC can be easily moved
  - Result: Moving the Operations center is very easy
    - Can be moved to another room, building, or even state!

# **Changes from Previous Missions**

- **IP based system**

- TRACE is the first SMEX mission designed for IP communications.
  - Allows data to be transferred more reliably
  - Allows easier access to the data from remote sites
  - Easier for trouble shooting line problems
- Result: Data can be easily and reliably forwarded to remote sites.
  - PI facilities
  - Test facilities

# **Changes from Previous Missions**

- **Remote Notification and Viewing**
  - WWW viewing capability
    - Allows anyone to view a pass with simply an Internet connection
  - Paging system monitors the spacecraft during unattended operations
  - Result: FOT can work normal business hours

# **Remote Notification**

- TRACE is using a paging system to alert the FOT if there are any problems on the spacecraft or ground system
  - Developed from Lotus Notes
  - Same system used during I&T for tracking anomalies
- After each pass, the ground system interrogates the event file to look for pre-defined limit violations, error messages, etc.
- An FOT member is paged and any parameters in error will be displayed on the pager.
  - Four people will be on call at all times
  - System scrolls to next person, if first person is unavailable
- FOT is then able to FTP data back from the server to their laptop to further diagnose the problem.

## **Remote Notification (cont)**

- The paging system has been extensively tested during I&T
- The system is working now in a shadow mode during the commissioning phase.
  - Ground system monitors spacecraft red/yellow limit violations, unexpected spacecraft event messages, and ground system messages
  - During commissioning, the FOT is further refining which parameters will require notification
    - Changes are controlled by the FOT

# **Functions Automated**

- Monitoring of spacecraft telemetry
- Monitoring of ground system
- Paging
- Interfacing with the ground stations
- Transferring engineering data to science workstations
  - Science data is FTP'd directly from the station
- Processing of engineering data (sub-setting parameters)

# Resulting Operational Changes

- TRACE is using a 5x8 work week versus earlier SMEX missions of 24x7
- FOT costs are reduced
- Hardware costs are reduced
- The spacecraft health and safety is still monitored throughout the day and weekends
- MOC is portable and can be easily moved allowing maximum flexibility
- Will test lights-out commanding in shadow-mode during nominal operations of TRACE to support WIRE
- *Ops concept will continue to evolve as more capabilities are realized*

## Early Lessons Learned

- Test your system as you will fly it at every opportunity you can. Mandate periodic test time for the FOT.
- Automation takes a great deal of up-front effort. Plan for it!
- Laptop computers provide the development team with a great deal of flexibility both pre- and post-mission
- Paging systems should be kept under FOT control
  - Plan the paging scenario during pre-launch
  - Prove it during commissioning
- ***Culture and Operations Concepts lag behind technology***
  - The TRACE team has expended a great deal of time and energy overcoming this obstacle



## **Future Work**

- WIRE and later SWAS will further build upon the work of TRACE
- Lights out commanding to be demonstrated on TRACE and used on WIRE
- After 6 months WIRE will enter an extended mission phase and be used as a flying testbed.
- Still more efficiencies will be achieved in the future as the ops concepts evolve
- Total lights-out operations being evaluated for extended and even future nominal SMEX missions